FCT Water Treatment

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Proposal for Consulting Services Agreement

Nebraska Public Power District Gerald Gentleman Station

Sutherland, NE

for

Assessment, Design and Implementation of Beneficial Waste Water Re-Use Treatment System

March 15, 2012

FCT Water Treatment is a recognized leader in water treatment technology in the utility, oil refining and chemical manufacturing industry. Formed by experienced *professionals*, FCT works with clients to provide cost effective, technically sound solutions.

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1.0 Scope

The scope of this proposal is to provide NPPD GGS with an integrated and comprehensive **Beneficial Waste Water Re-Use Treatment System** for the purpose of reducing environmental impact and optimizing processes, including but not restricted to re-use of:

- The existing site waste water (Evaporation Pond)
- The Waste Water Recovery System water
- The planned limestone scrubber water systems.

In this proposed agreement, FCT Water Treatment will provide technical consulting services to produce a design, which meets these goals related to basic chemistry control parameters, specifying equipment acquisition, address environmental compliance issues, and treatment process implementation.

The overall course the consulting services are to perform :

- Detailed evaluation of the existing internal plant waste water streams including chemical analyses, flow and the impact on plant operations on variations in chemistry and flow.
- Predictive modeling of the chemistry and water balance to determine the impact of produced water quality (composition) and most important, the variability of water quality on the operation of each stage of the system. The predictive modeling will include calculation of scaling indices, corrosion potentials, zeolite softener performance, RO performance, scrubber recovery efficiencies and solids removal/handling.
- Design of the waste water re-use system based upon the predictive modeling and practical experience with industry best practices. The system design will be comprised of a detailed specification of major equipment components, budgetary cost estimates and overall operational guidelines.
- Prior to implementation, validation of the system design including coordination of site visits to existing installations and survey of current industry best practices.

The consulting services provided by FCT Water Treatment are intended to be both responsive to NPPD GGS oversight and proactive in providing feedback - *guidance and direction* - related to the project.

2.0 Objective

To design a system including complete equipment specifications for onsite wastewater re-use. Proposed minimum the overall design objectives are:

- To treat 400 gpm minimum, continuous capacity

- Accept waste water influent, with mixed and variable composition typically bottom ash water, bottom ash pond, floor drain run off, sodium zeolite regeneration waste and RO reject.

- Produce effluent water quality for various potential in plant uses including but not limited to:
    - *Limestone scrubber make-up (future use)*
    - *Make-up water to evaporative cooling tower for auxiliary HVAC system*
    - *Supplemental make up to existing boiler feed water treatment system*
    - *Fly ash handling and dust suppression*
    - *General service water*

- Produce waste solid material, adequately dewatered and conditioned for either on site storage or off site disposal.

3.0 System Description

The final design produced will be directed by GGS site needs. A description of typical system components used for wastewater treatment systems are summarized below. Also refer to Appendix for basic process flow diagrams for the systems, general equipment list and budgetary estimates.

Wastewater Re-Use Treatment System

The proposed Beneficial Waste Water Re-Use Treatment System is a Near Zero - or Zero - Liquid Discharge (ZLD) Treatment System. The System will remove or reduce both soluble and non- soluble solids from the wastewater, producing conditioned, solid waste acceptable for onsite storage or off-site disposal and distilled water for reuse.

A typical ZLD System may consist of the following sub-systems. One or more of these treatment steps may be optional based upon the planned final use of the effluent product water:

a. Lime-Soda Softening with solids dewatering
b. Multimedia Pressure Filtration
c. Zeolite Softening - optional

d. Reverse Osmosis (RO) - optional
e. Forced Circulation (FC) Crystallization with solids dewatering - optional

Lime-Soda Softening System

A Lime-Soda Softening treatment system removes suspended solids from the wastewater and precipitates calcium (Ca), magnesium (Mg), and silica (SiO2). The removal of these suspended solids and ions from the wastewater will produce effluent water of sufficient quality to be used directly as Limestone Scrubber Make-Up or other general plant service water or alternatively to allow a downstream Reverse Osmosis (RO) System to operate at maximum efficiency.

The plant will collect the wastewater from the plant in an effluent tank where it will be homogenized or alternatively in a collection pond. The wastewater will be mixed and variable composition made up of, but not limited to the following sources:

- Bottom ash water
- Aux. Cooling Tower Blow down
- Zeolite Softeners Regeneration Waste
- Filter Press Filtrate Sump Return
- Plant RO Reject
- Drain run-off

From the effluent tank, the wastewater will be fed to the IDI/WPT wastewater treatment system. It will first enter the Rapid Mix Tank. The flow to the Rapid Mix Tank is controlled via a flow control valve. Lime and coagulant (Ferric Chloride) are added to the Rapid Mix Tank. Lime is added to raise the pH to induce the precipitation of Calcium Carbonate (CacO3), Ferric Hydroxide (Fe(OH)3), and Magnesium Hydroxide (Mg(OH)2). The production of the Mg(OH)2 is very important, because SiO2 is absorbed into the Mg(OH)2 particles during the chemical precipitation reaction. The removal of silica will greatly reduce the scaling potential of in the downstream limestone scrubber system and, alternatively the downstream RO System, which will allow the RO to operate at a high recovery. Ferric Hydroxide precipitation will aid in the production of stable particles (floc).

The wastewater will then flow into the DensaDeg Reactor, where Soda Ash (Na2CO3) and Anionic Polymer will be added. The Soda Ash will induce the precipitation of the remaining soluble Ca++. Again, the replacement of Ca++ ions in the water with Na+ ions will greatly reduce the chances of scaling in the downstream limestone scrubber system and, alternatively of the downstream RO System, which will allow for a high recovery rate (>85%). Polymer is injected into the DensaDeg Reactor to aid in the flocculation and settling of the precipitated and coagulated particles.

After leaving the DensaDeg Reactor, the chemically treated wastewater will flow into the DensaDeg Clarifier/Thickener Tank, were the formed solids will separate from the water and settle to the bottom of the tank. The clean water will flow out of the DensaDeg Clarifier/Thickener Tank via a lamella tube area, which will ensure a low TSS (on average < 5 mg/l) effluent. The settled sludge will be mechanically thickened (on average sludge concentration > 15%) by a scraper rake at the bottom of the tank. A part of the sludge inventory is recycled back to the influent piping to the DensaDeg Reactor, thereby increasing the solids in the reactor and improving the performance of the process, especially SiO2 removal. This internal recycling of previously formed solids (sludge) enhances the solids contact process and increases the speed of the reactions. While a fraction of the sludge is recycled most is wasted to the sludge storage tank, where it is stored and then processed through the solids dewatering system.

Sulfuric acid (H2SO4) is added to the clarified water to reduce and control the pH as required for the downstream processes.

Lime-Soda System Solids Dewatering System

The sludge in the sludge storage tank is processed through the solids dewatering system on a 7-day/week and 8-hour/day operational basis. The sludge is pumped into one (1) 100% Recessed Chamber Filter Press, where it is dewatered. The estimated sludge cake (dewatered sludge) characteristics will be on average 40% moisture content and density of 90 lbs/ft3. The sludge cake will fall into roll-off bins, which are stationed below. The filtrate from the sludge dewatering process will flow into the Master Sump for storage and recycle. The filtrate will be pumped back to the 3-day Wastewater Equalization Storage Tank to ensure homogenized wastewater.

The recycle of all wastewater back to the Wastewater Equalization Storage Tank is very important element in the overall process. By recycle back to the Wastewater Equalization Storage Tank, instead of the DensaDeg, the system ensures that the limestone scrubber make-up, or alternatively the Reverse Osmosis System does not see wide swings in either flow or TDS concentration.

Reverse Osmosis System (optional)

Water from the lime softener is fed from the clear well through multimedia filters to remove particulate matter which may have carried over from the clarifier. This filtered water then passes through polishing zeolite softeners to reduce the hardness of the lime-softened water from approximately 3 grains per gallon to near zero. Sodium bisulfite is injected into the feed water to remove any FAC, which may be present, and then antiscalant is added to inhibit scale formation on the RO membranes. The water is further filtered by 5 μ cartridge filters and is then fed to the RO system.

A single 100% RO is provided, but 2 x 100% installed pumps are included on the system for redundancy. This RO employs 6 pressure vessels, each containing six
8" by 40" TFC membranes, and these pressure vessels are arranged in 4:2 array. Reject recirculation is used to achieve a 90% recovery. When 114 gpm is fed to the RO system, approximately 103 gpm of permeate are produced to be used in the plant, and approximately 11

gpm of concentrated brine is produced, which is collected in the crystallizer feed tank and pumped to the crystallizer.

A permeate flush pump skid is also provided. During each shutdown of the RO system and at other preprogrammed times, the membranes on the RO will be flushed with RO permeate to keep them clean and to reduce the potential for mineral scale formation. A clean-in-place system (CIP) is also provided so that the RO elements can be periodically cleaned with high and low pH solutions.

Forced Circulation (FC) Crystallizer System (optional)

The purpose of the FC Crystallizer System is to evaporate the reject water from the RO system in order to reuse this water within the cooling towers. The Forced Circulation Crystallizer (FC) section consists of one (1) 100% Forced Circulation Crystallizer with one (1) Centrifuge for solids dewatering.

The RO reject water enters the FC Crystallizer Feed Tank. The wastewater is then pumped into the FC Crystallizer System. To improve the energy efficiency of the FC Crystallizer System, the wastewater is preheated by a liquid/liquid preheater before this flow is combined with the concentrate from the Centrifuge in the mother liquor tank.

The wastewater is then mixed with the liquid content of the FC Crystallizer loop. Two (2) Turbo Fans in series are utilized to provide heat for the FC Crystallizer heater. In passing through the tubular heater, the temperature of the liquid in the FC Crystallizer loop is increased without boiling in order, thus avoid scaling on the heat transfer area. The hydrostatic head of the liquid on top of the heater prevents the liquid from boiling at this temperature. The heated liquid leaves the heater and enters the FC Crystallizer Vessel, where the hydrostatic pressure is released and the liquid starts to flash, since the liquid temperature is higher than the boiling temperature defined by the vapor pressure. The liquid concentration has now increased past the solubility point of the dissolved inorganic salts in solution, thus causing crystallization.

To prevent scaling and encrustations, the most affected sidewall areas within the crystallizer vessels are polished. The Crystallizer Vessel is designed with low upward velocity to minimize the amount of entrained droplets. In addition, the Crystallizer Vessel is equipped with a demister to remove any droplets before leaving the vessel. The combination of low upward velocities and demister ensures a good condensate/distillate quality.

The generated flash vapor from the FC Crystallizer is condensed in a shell and tube surface condenser. All process condensate generated from the wastewater is collected in a common condensate tank and later transferred to the battery limits.

Dewatering Section

A slurry stream, containing the salt crystals, is extracted from the FC crystallizer loop to remove the inorganic salts from the system. The slurry is fed directly into a centrifuge. The produced salt cake (wet solids) will normally have a maximum moisture content of 10%. This wet cake will fall into a roll-off bin (or similar). The excess concentrate (mother liquor) is collected in the Mother Liquor Tank underneath the Centrifuge and recycled back to the FC Crystallizer.

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4.0 Resources and Cost

FCT Water agrees to provide up to 40 man-days of professional consulting services during the period beginning March 15, 2012 and ending December 31, 2012.

Payments NPPD shall pay to FCT Water Treatment a fee of US$100,000 (one hundred thousand US dollars) payable in 9 equal monthly payments of US$11,111 (eleven thousand, one hundred and eleven US dollars). FCT Water Treatment shall keep records of time spent on NPPD business and send monthly updates. If the allotment is used up by the end of the Term, FCT Water Treatment may submit invoices for agreed upon hours exceeding the allotment at the rate of US$350 per hour.

Reimbursement of Expenses. FCT Water Treatment may incur reasonable and pre-approved expenses including travel and other agreed upon items. Expenses shall be reimbursed within thirty (30) days of FCT Water presenting NPPD with an itemized account of the expenditures.

5.0 Services and Personnel

Services provided to NPPD may include technical consulting, engineering/design specifications, mathematical modeling of water systems and water use balance, training, inspections and other items agreed upon.

Unless otherwise agreed upon by both parties, FCT Water Treatment personnel will provide all consulting services as part of this proposed agreement.

The services will be provided primarily by Alexander C. McDonald, Ph.D. and Gene Decker.

6.0 Terms and Confidentiality

Confidential Information. For purposes of this agreement Confidential Information means any information, however transmitted or disclosed by NPPD to FCT Water Treatment including but not limited to:

a. Records, receipts, specifications, analyses, studies, engineering data, models, proposals, notes, memoranda and interpretations related to NPPD business.

b. Commercial, contractual, legal and financial information pertaining to NPPD business, including but not limited to contracts, proposals, models, marketing analyses, market plans, investment and project development agreements, letters of intent, memoranda of understanding and budgets.

c. Trade secrets, including but not limited to application trade secrets.

In consideration of the covenants and obligations contained herein, FCT Water Treatment agrees that all Confidential Information shall be kept strictly confidential and shall not be sold, traded, published or otherwise disclosed to any person or entity without the explicit written approval of NPPD. FCT Water Treatment further agrees not to reproduce any Confidential Information without the written consent of NPPD. FCT Water Treatment further agrees that it shall safeguard and protect all Confidential Information received as part of this agreement and take all reasonable steps to maintain the confidentiality of any Confidential Information disclosed by NPPD.

This Agreement shall be construed and interpreted in accordance with the laws of the state of Nebraska. All disputes between FCT Water Treatment and NPPD will be subject to binding arbitration in NPPD Company specifically agree that any arbitration between parties shall take place in Nebraska.

This Agreement inures to the benefit of, and is binding upon the respective successors of the parties.

This Agreement is not assignable.

Signed this ________ day of __________________________, 2012

NPPD ____

By ____

It's ________________________________

FCT Water Treatment, Inc.

By ____

It's _President__________________________

Appendix I Basic Equipment List

NPPD Gerald Gentleman Station

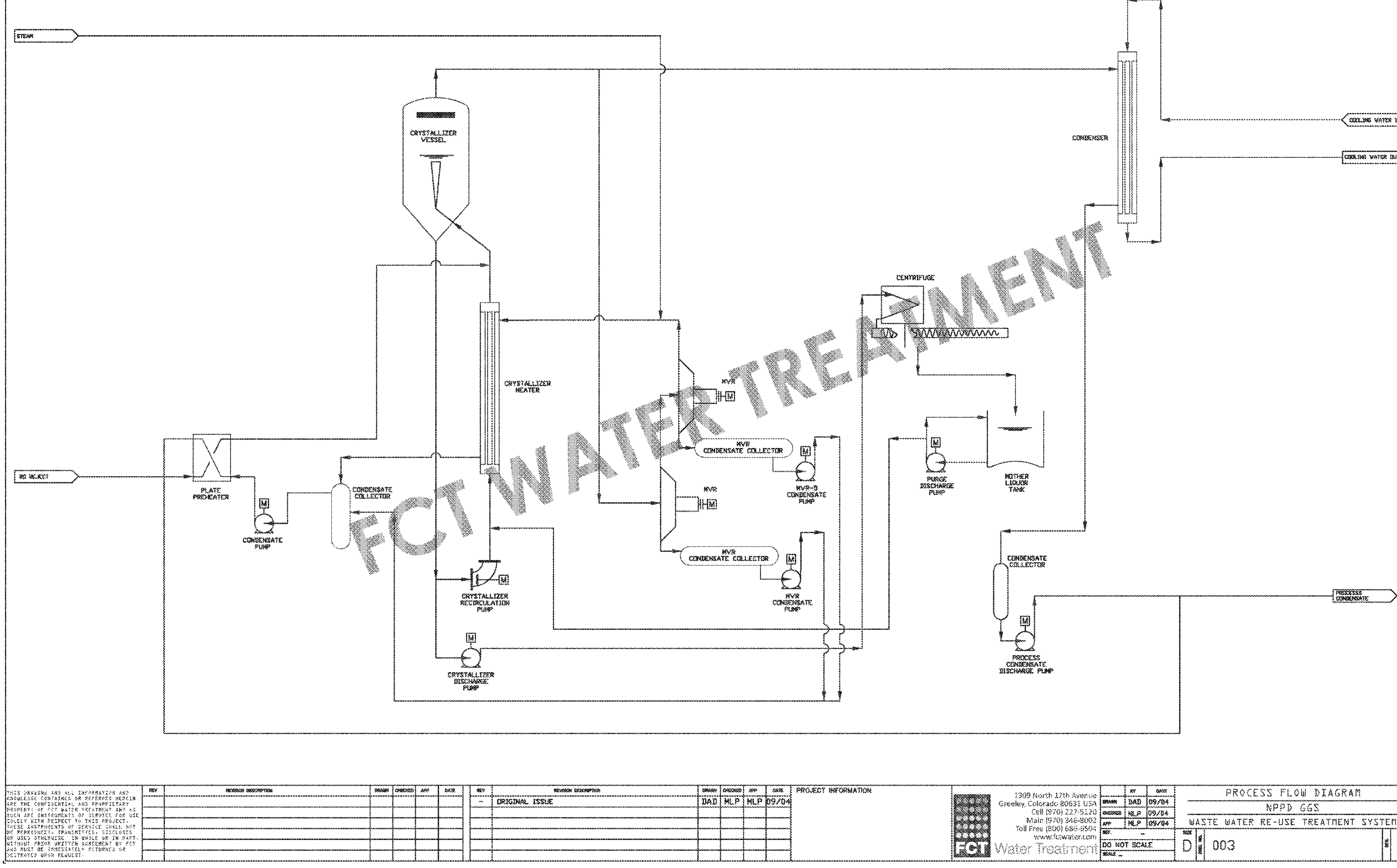
Waste Water Reuse System	**$5,500,000**	**Budget Estimate for 400 gpm System**
Expected Annual Operation	%	100
Wastewater EQ tank		
Volume	gal	600000
Static Head	psi	0.3 - 9.1
Wastewater Feed Pumps		
Flow	gpm	400
Pressure	psi	30
Rapid Mix Tank with Mixer:		
Tank Diameter	ft	3
Tank Height	ft	11
Retention Time	min	2.75
Tank MOC		Expoxy Lined Carbon Steel
Mixer MOC		Stainless Steel
Rapid Mix Dosed Chemicals		Lime, $FeCl_3$, $MgCl_2$
Reactor Vessel		
Tank Diameter	ft	5
Tank Height	ft	16
Retention Time	min	10
Tank MOC		Epoxy Lined Carbon Steel
Mixer MOC		Epoxy Lined Carbon Steel
Reactor Dosed Chemicals		Soda Ash, Polymer
Clarifier		
Tank Diameter	ft	7
Tank Height	ft	16
Retention Time	min	10
Tank MOC		Epoxy Lined Carbon Steel
Post Clarifier Dosed Chemicals		Sulfuric Acid
Sludge Recycle Pump		
Flow	gpm	20
Pressure	psi	30
Sludge Waste Pump		
Flow	gpm	20
Pressure	psi	30
Sludge Holding Tank		
Volume	gal	2500
Tank Diameter	ft	12
Tank Height	ft	10
MOC		FRP
Filter Press Feed Pumps		
Flow	gpm	40 @ 10 psi
Flow	gpm	15 @ 100 psi
Filter Press		
Operation	hr/day	16
Capacity	ft^3	25
Min Cake Solids	%	35

Filter Press Filtrate Surge Tank		
Volume	gal	1200
Tank Diameter	ft	5.75
Tank Height	ft	9.083
MOC		cross-linked polyethylene
Clearwell Tank		
Volume	gal	10000
Tank Diameter	ft	12
Tank Height	ft	12.5
Retention Time	min	50
MOC		FRP
Multimedia Filter Feed Pumps		
Flow	gpm	200
Pressure	psi	70
Multimedia Filter Backwash Pumps		
Flow	gpm	690
Pressure	psi	45
Multimedia Filter		
Tank Diameter	ft	7
Tank Hieght	ft	6
MOC		Expoxy lined carbon steel
Media - Gravel	ft^3	50
Media - Garnet	ft^3	34
Media - Sand	ft^3	34
Media Anthrocite	ft^3	34
Zeolite Softener		
Configuration		2 x 100%, alternating
Tank Diameter	ft	4.5
Tank Hieght	ft	6
MOC		Expoxy lined carbon steel
Resin		TBD
Zeolite Brine Tank		
Tank Diameter	ft	5.5
Tank Hieght	ft	6
Capacity	gal	1000
Salt capacity	lbs	2000
MOC		HDPE
Brine Concentation	% NaCl	26
Brine Forwarding Pump		
Flow	gpm	25
Pressure	psi	30
HERO Cartridge Filters:		
Filters		2 x 50%
Cartridge Type		TBD
Cartridge Diameter	inches	2.5
Cartridge Length	inches	40
Cartridge per housing	each	19
Pore size	micron	5
HERO Booster Pump 1 (one per RO unit)		
Flow	gpm	222
Pressure	psi	321

HERO Interstage Booster Pump (one per RO unit)		
Flow	gpm	101
Pressure	psi	176
High Efficiency Reverse Osmosis (HERO):		
Configuration		2 x 100%
Min Water Recovery	%	90
Vessel Arrangement		1 pass, 2 stages with interstage booster pumps
RO Feed Water Flow	gpm	222
First Pass		
Product Flow for stage 1	gpm	101
Vessels per Stage		6
Membranes per Vessel		7
Membrane Type		Hydronautics CPA5-LD
Second Pass		
Product Flow per Stage	gpm	71
Vessels per Stage		3
Membranes per Vessel		7
Membrane Type		Hydronautics CPA5-LD
CIP Skid		
same as demin system CIP skid		
Dendsadeg Polymer Dosing Pump		
Chemical Type		30% to 100% Neat Polymer
Injection Point		Polymaster Mix Chamber
Chemical Pump		Grundfos DME 2-18
Pump Flow	gph	0.66
Discharge Pressure	psig	90
Dilution Water Flow	gpm	5
Final Injection Point of Dil. Polymer		Densadeg reactor
Magnesium Chloride Dosing Pump		
Chemical Type		35% Magnesium Chloride
Injection Point		Densadeg rapid mix tank
Chemical Pump		Grundfos DME 8-10
Pump Flow	lph	1.98
Discharge Pressure	psig	145
Ferric Chloride Dosing Pump		
Chemical Type		41% Magnesium Chloride
Injection Point		Densadeg rapid mix tank
Chemical Pump		Grundfos DME 8-10
Pump Flow	lph	1.98
Discharge Pressure	psig	145
Lime Dosing System		
Chemical Supplied		98% Hydrated Lime
Lime Feeder Capacity	lb/hr	300
Lime Slurry Concentration	%	10
Pump Flow	gpm	40, a portion is recycled
Injection Point		Densadeg rapid mix tank
Desired pH		11.2, doisng of 10% lime slurry controlled by pH of rapid mix tank

Soda Ash Dosing System		
Chemical Supplied		98% Hydrated Lime
Soda Ash Feeder Capacity	lb/hr	300
Soda Ash Slurry Concentration	%	10
Pump Flow	gpm	30, a portion is recycled
Injection Point		Densadeg reactor
Sulfuric Acid Pump		
Chemical Type		93% Sulfuric Acid
Injection Point		After the clarifier but before clearwell
Chemical Pump		Grundfos DME
Pump Flow	gph	1.98
Discharge Pressure	psig	145
Dilution Water Flow	gpm	
HERO Antiscalant		
Chemical Type		TBD by bidder
Injection Point		before RO cartridge filter
Chemical Pump		Grundfos DME
Pump Flow	gph	0.66
Discharge Pressure	psig	261
HERO Sodium Bisulfite		
Chemical Type		39% Sodium Bisulfite
Injection Point		after RO cartridge filter
Chemical Pump		Grundfos DME
Pump Flow	gph	1.75
Discharge Pressure	psig	100

Appendix II Process Flow Diagrams



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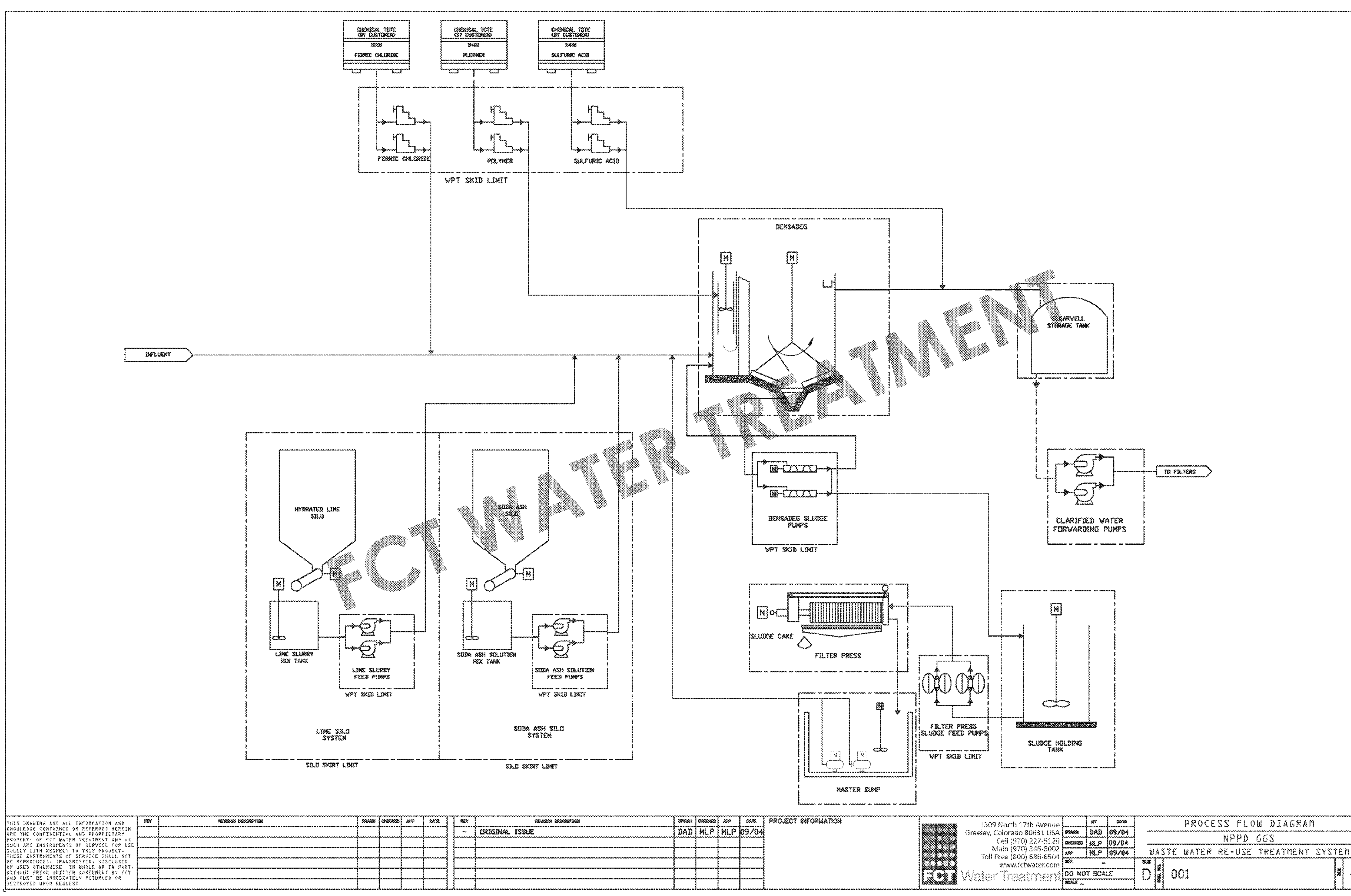

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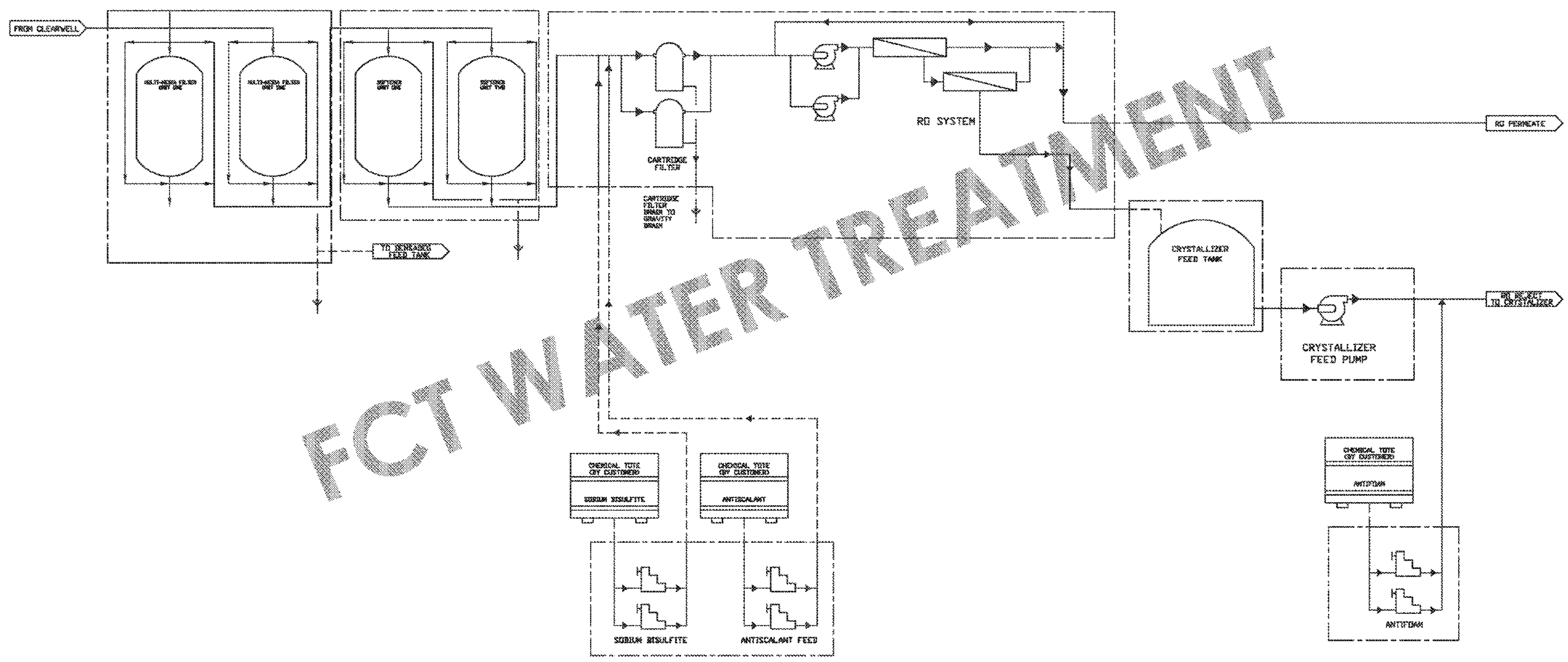

REV	REVISION DESCRIPTION	DRAWN	CHECKED	APP	DATE
–	ORIGINAL ISSUE	DAD	MLP	MLP	09/04

PROJECT INFORMATION

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DO NOT SCALE
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PROCESS FLOW DIAGRAM
NPPD GGS
WASTE WATER RE-USE TREATMENT SYSTEM

SIZE D DWG NO. 002 REV. –

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